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# The Distribution of Leaves and Pear Psylla in Pear Trees

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## ABSTRACT

The distribution of leaves in pear trees is highly variable and is apparently dependent on many horticultural practices, particularly pruning. In the pear trees studied, the largest number of leaves (46 to 57 percent) originated on vegetative spurs with smaller numbers (18 to 32 percent) on new wood growth and fruit spurs (21 to 24 percent). Although the variability between trees and between orchards was great, the leaf area per fruit (508 to 561 cm ) was consistant. The eggs and nymphs of the pear psylla, *Psylla pyricola* Foerst., were unevenly distributed on the pear trees studied. The numbers of immature pear psylla were not significantly different at three heights or on the four sides of the tree. Largest populations occurred on new foliage with concentrations on the fruit spur foliage in early season and on the new wood foliage in midseason.

**KEYWORDS:** Pear trees, leaf distribution, pear psylla, *Psylla pyricola*, pear psylla distribution.

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# THE DISTRIBUTION OF LEAVES AND PEAR PSYLLA IN PEAR TREES<sup>1</sup>

By Robert E. Fye<sup>2</sup>

## INTRODUCTION

Entomologists attempting to determine the extent of insect populations in complex environments are generally restricted to small samples from which they must project population estimates. Knowledge of plant structure is essential to formulate this estimate. In addition, plants form the universe that parasites and predators must search to detect their host or prey. A study of leaf distribution in pear trees was made to enable population estimates of pear psylla, *Psylla pyricola* Foerst., and to ascertain the leaf surface that predators must search to detect the pest. Certain structural aspects of the pear tree were also examined. Willett (6)<sup>3</sup> correlated leaf surface with cross sectional areas of individual limbs and found a close relationship. In addition, a study of pear psylla egg and nymph distribution was conducted from 1977 to 1979 in an unsprayed orchard to determine the potential patterns of the immature pear psylla in pear trees. Orchard managers sampling for pear psylla can use the distributions of leaves and psylla to minimize the bias associated with selecting samples taken within arm's reach.

## METHODS AND MATERIALS

The basic methods used to determine the leaf distribution was modified from Heinicke (3). Two planes through the center of selected trees, one in the direction of the row and one perpendicular to the row, were delineated with sash cords held taut with light springs and attached to five plastic pipe standards: one on each side of the tree and one in the center of the tree (fig. 1). The sash cords were placed 0.5 m apart on the vertical axis parallel to the soil. The horizontal limit of each 0.5-m section was a colored ring on the cord. A sliding guide wire (fig. 1), 0.5 m in length and centered on each cord, defined the width of the 0.125-m<sup>3</sup> portion of tree to be examined.

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<sup>3</sup>Italic numbers in parentheses refer to Literature Cited, p. 15.

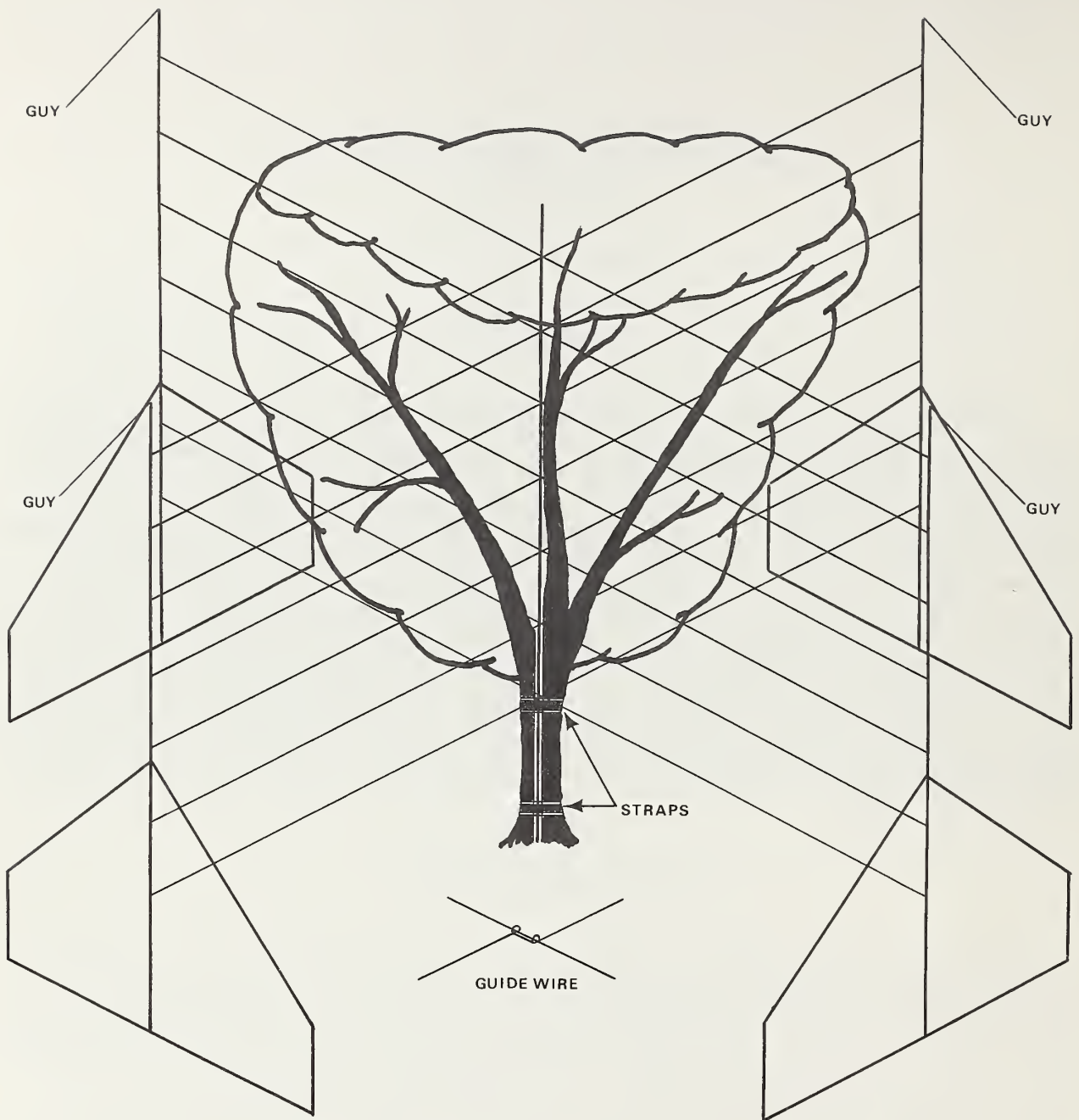


Figure 1.--Field placement of the measurement standards in a pear tree with an enlarged view of the guide wire for measuring the width of the sample cube.

The leaves in each cube were counted using the following designations: (1) fruit spur leaf--leaves on spurs bearing a developing fruit; (2) vegetative spur leaf--leaves on any vegetative spur with three or more leaves, or fruit spurs that shed all fruit, or terminals less than 10 cm in length; (3) terminal leaf--leaves on terminals more than 10 cm in length with origins in fruit spurs or adventitious buds; and (4) miscellaneous leaf--scattered leaves, that is, one or two leaves not associated with spurs or shoots. All leaves on a spur originating in the sample cube were included in that cube; however, in the case of terminals and shoots, only the leaves actually originating in the cube were included. In the center of the tree, where sample cubes overlapped, leaves occurring in two sample cubes were counted in one.

The leaves in four trees in each of three orchards were counted. All trees were Bartlett's on seedling rootstock. The ages of the trees were 15, 20, and 23 yr for growers 1, 2, and 3, respectively. The tree rows were on 6-m spacing with trees 6 m apart in the row. All orchards were interplanted with 2- to 3-yr-old trees midway between the older trees. Grower 1 fertilized at a rate of 0.5 kg of N per tree, but growers 2 and 3 did not fertilize in 1979. No water stress occurred in the orchards; growers 1 and 2 employed overhead sprinkler irrigation, and grower 3 used undertree sprinklers.

At the time of the count, 50 leaves from each designated category were picked and measured with an electronic area meter to determine the mean leaf area. After the fruit had been picked and before the leaves had started to drop, 8 of the 12 trees sampled in two orchards during the summer were covered with parachutes. Premature leaf fall due to phytophagous mite damage precluded suitable measurement of the remaining four trees. One chute was placed under the tree and one over the tree, and the two chutes were tied together at about midtree. The leaves from each tree were collected as they dropped and were counted as they were measured with the electronic leaf meter.

In the preliminary study of immature pear psylla distribution in 1977, the tree crowns were divided in thirds and designated low, mid, and high. During March, five fruit spurs were sampled at each level in 13 trees. From April 11 to May 2, two fruit spurs were sampled, and from May 9 to October 3, 10 randomly selected leaves were taken from the high and midlevels and 5 from the low level. All pear psylla eggs and nymphs on the leaves were counted under magnification in the laboratory.

In both 1978 and 1979, four trees were sampled weekly. The trees were divided into 12 quadrants comprised of three levels, 2, 3, and 4 m above the soil surface, and four sides, two in the direction of the row and two in the center of the row. Due to the orientation of the orchard, the two in-row samples were the north and south sides of the tree and the center row sides were the east and the west. The sampling units in each quadrant were adjusted to the growth of the tree as noted in table 1. The minimal growth of the shoots in 1979 precluded division of the leaves into old and new leaves, and the shoot leaves were randomly selected. All leaves were removed to the laboratory and inspected under magnification for the presence of eggs and nymphs.

In 1979, populations of predators and parasites attained a level that warranted an attempt to correlate the distribution of the beneficials with that of the immature pear psylla. On April 23, 10 vegetative spurs and 10 fruit spurs at 2-, 3-, and 4-m levels were inspected on four trees in the field. From

Table 1.--Sampling units for pear psylla distribution

No. of spurs or leaves per sample in each quadrant									
Dates	Spurs			Leaves			Shoot <sup>3</sup>		
	Fruit	Vegetative <sup>1</sup>	Fruit spur	Vegetative spur	Fruit and Vegetative spur <sup>2</sup>	Early <sup>4</sup>	Mid <sup>5</sup>	Late <sup>6</sup>	Over-all
1978:									
Mar. 27-Apr. 10	5								
Apr. 24 <sup>1</sup>	3	2							
May 1	3			8					
May 15			6	6				6	
May 22-Aug. 7			6	6		6		6	
Aug. 14					12				12
Aug. 21-28					12				6
1979:									
Mar. 29-Apr. 6	3								
Apr. 23	3	2							
Apr. 30			9	6					
May 7-28			6	6					6
June 4-Aug. 20			6	6					6
Aug. 27					6				6

<sup>1</sup>Nonfruiting spurs.<sup>2</sup>Leaves taken randomly from all spurs.<sup>3</sup>All new woody growth.<sup>4</sup>Leaves from earliest 6 leaves on shoot.<sup>5</sup>Leaves from middle of shoot.<sup>6</sup>Leaves from latest 6 leaves on shoot.

April 30 through June 25, developing terminals were present and 10 terminals were inspected at each level. As the spurs and terminals were inspected, the numbers of predators and parasites detected were recorded. The beneficial insects included *Trechmites* sp. adults; all stages of hemipteran predators, mainly *Anthocoris* spp. and *Deraeocoris* sp.; all stages of lady beetles, mainly *Adalia bipunctata*; all stages of spiders; and the predatory stages of other species.

## RESULTS AND DISCUSSION

The numbers of leaves and the leaf area and the proportional distribution in relation to their origin and height in the tree are presented in tables 2 to 4. The fruit distribution in relation to the height in the tree is presented in table 5.

Table 2.--Numbers of leaves and leaf area originating on spurs and new growth of pear trees

		Number of leaves or leaf area originating on--					
Grower	Tree No.	Vegetative spurs	Fruit spurs	Shoots	Miscellaneous leaves <sup>1</sup>	Estimated <sup>2</sup>	Actual <sup>3</sup>
<i>No. of leaves (thousands)</i>							
1	1	16.1	7.2	8.3	0.5	32.1	23.5
	2	19.6	8.2	16.3	.5	44.5	31.1
	3	17.7	6.7	7.7	.1	32.1	27.7
	4	10.0	7.2	11.9	.3	29.5	21.5
	Mean	15.9	7.3	11.0	.4	34.6	25.9
2	1	22.9	9.6	12.0	.8	45.4	--
	2	20.2	10.7	12.0	1.0	43.9	--
	3	16.7	10.2	12.3	.9	40.1	--
	4	17.6	9.7	9.4	.5	37.2	--
	Mean	19.4	10.0	11.4	.8	41.6	--
3	1	21.8	6.9	8.2	1.3	38.3	48.8
	2	30.0	10.8	11.2	1.6	53.5	38.6

Table 2.--Numbers of leaves and leaf area originating on spurs and new growth of pear trees--Continued

		Number of leaves or leaf area originating on--					
Grower	Tree No.	Vegetative spurs	Fruit spurs	Shoots	Miscellaneous leaves <sup>1</sup>	Estimated <sup>2</sup>	Actual <sup>3</sup>
<i>No. of leaves (thousands)</i>							
3	3	21.8	8.1	7.6	1.4	38.9	43.0
	4	25.8	11.7	4.2	1.2	42.9	39.5
	Mean	24.8	9.4	7.8	1.4	43.4	42.4
<i>Leaf area (m<sup>2</sup>)</i>							
1	1	33.8	10.9	17.5	.7	62.9	45.8
	2	41.1	12.3	35.9	.7	89.9	61.2
	3	34.3	9.9	18.1	.1	62.4	49.8
	4	21.4	12.3	25.4	.6	59.7	39.6
	Mean	32.6	11.4	24.2	.5	68.7	49.1
2	1	51.1	14.6	26.0	1.8	94.4	--
	2	43.2	17.5	27.9	2.0	90.7	--
	3	36.4	18.3	23.7	1.9	80.3	--
	4	32.6	16.3	18.3	1.0	68.2	--
	Mean	40.8	16.7	24.2	1.7	83.4	--
3	1	46.3	10.8	19.7	2.8	79.7	90.3
	2	61.2	18.1	28.0	3.2	110.5	67.8
	3	46.4	12.8	18.5	3.0	80.6	85.3
	4	46.4	17.8	10.7	2.2	77.1	57.5
	Mean	50.1	14.9	19.2	2.8	87.0	75.2

<sup>1</sup>Scattered leaves not associated with spurs or shoots.

<sup>2</sup>Estimated by the method of Heinicke (3).

<sup>3</sup>Leaf count at leaf fall with area determined by an electronic area meter.

Table 3.--Distribution of leaves at 3 levels in pear trees with origin of leaves

Proportion <sup>1</sup> of leaves originating in the indicated meter above soil surface		1 m	2 m	3 m	4 m	Total
Grower	Leaves on--					
1	Vegetative spurs	0.05(0.01-0.06)	0.21(0.17-0.25)	0.15(0.10-0.20)	0.06(0.02-0.08)	0.46(0.34-0.55)
	Fruit spurs	0.03(<.01- .04)	.10( .07- .15)	.07( .05- .08)	.02( .01- .03)	.21( .18- .25)
	Shoots	.01(<.01- 0.3)	.11( .09- .14)	.10( .06- .15)	.10( .07- .12)	.32( .24- .40)
	Miscellaneous	<.01	<.01	<.01	<.01	.01(<.01- .02)
	Total	.09( .02- .12)	.42( .36- .51)	.32( .28- .34)	.17( .12- .23)	
2	Vegetative spurs	.01( .01- .03)	.18( .16- .21)	.17( .14- .21)	.10( .07- .13)	.47( .42- .50)
	Fruit spurs	<.01	.06( .06- .08)	.10( .09- .10)	.08( .04- .11)	.24( .21- .26)
	Shoots	<.01	.05( .04- .07)	.08( .06- .10)	.13( .11- .17)	.27( .25- .31)
	Miscellaneous	<.01	.01	.01	<.01	.02( .02- .02)
	Total	.02( .01- .05)	.31( .28- .33)	.36( .29- .40)	.31( .22- .42)	
3	Vegetative spurs	.01( 0- .02)	.19( .15- .22)	.19( .15- .22)	.19( .15- .21)	.57( .56- .60)
	Fruit spurs	<.01	.05( .03- .07)	.08( .04- .09)	.09( .08- .11)	.22( .18- .27)
	Shoots	<.01	.02( .01- .04)	.05( .04- .07)	.11( .04- .16)	.18( .10- .21)
	Miscellaneous	<.01	.01( .01- .02)	.01	.01	.03( .03- .04)
	Total	.01( 0- .02)	.27( .21- .32)	.32( .25- .38)	.40( .37- .42)	

<sup>1</sup>Mean followed by range of 4 trees in parentheses.

Table 4.--Distribution of leaf surface at 3 levels in pear trees with origin of leaves

Proportion <sup>1</sup> of leaf surface originating in the indicated meter above soil surface		1 m	2 m	3 m	4 m	Total
Grower	Leaves on--					
1	Vegetative spurs	0.05(0.01-0.07)	0.22(0.18-0.27)	0.15(0.10-0.20)	0.06(0.02-0.09)	0.48(0.36-0.54)
	Fruit spurs	.02(<.01-.03)	.08(.05-.12)	.05(.04-.07)	.02(.01-.02)	.17(.14-.21)
	Shoots	.02(<.01-.03)	.12(.10-.15)	.11(.07-.16)	.11(.07-.14)	.35(.28-.43)
	Miscellaneous	<.01	<.01	<.01	<.01	<.01
	Total	.08(.02-.12)	.42(.36-.51)	.31(.28-.34)	.18(.13-.24)	
2	Vegetative spurs	.02(.01-.03)	.19(.16-.23)	.18(.14-.21)	.10(.07-.14)	.49(.45-.54)
	Fruit spurs	<.01	.05(.04-.08)	.08(.07-.09)	.06(.03-.08)	.20(.16-.24)
	Shoots	<.01	.05(.04-.07)	.09(.07-.10)	.14(.12-.19)	.29(.27-.31)
	Miscellaneous	<.01	.01	.01	<.01	.02(.02-.02)
	Total	.02(.01-.04)	.31(.28-.34)	.35(.28-.40)	.32(.22-.42)	
3	Vegetative spurs	.01( 0-.02)	.19(.15-.22)	.19(.15-.22)	.19(.15-.20)	.58(.55-.60)
	Fruit spurs	<.01	.04(.02-.06)	.06(.03-.08)	.07(.06-.09)	.17(.14-.23)
	Spoots	<.01	.02(.01-.04)	.06(.04-.09)	.14(.06-.20)	.22(.14-.25)
	Miscellaneous	<.01	.01(.01-.02)	.01	.01	.03(.03-.04)
	Total	.01( 0-.02)	.26(.21-.32)	.32(.25-.38)	.41(.37-.42)	

<sup>1</sup>Mean followed by range of 4 trees in parentheses.

Table 5.--*Ratios of numbers of leaves in pear trees in the 1st, 3d, and 4th meters above the soil surface to numbers in the 2d meter, and ratios of fruit spur, shoot, and miscellaneous leaves to numbers of vegetative leaves*

Grower	Leaves on--	Ratios of numbers of leaves to the following heights				Ratios of leaf types
		1 m	2 m	3 m	4 m	
1	Vegetative spurs	0.24	1	0.71	0.29	1
	Fruit spurs	.30	1	.70	.20	.46
	Shoots	.09	1	.91	.91	.70
	Miscellaneous	--	1	--	--	.02
	Total	.21	1	.76	.40	
2	Vegetative spurs	.06	1	.94	.56	1
	Fruit spurs	--	1	1.66	1.33	.51
	Shoots	--	1	1.66	2.66	.57
	Miscellaneous	--	1	--	--	.04
	Total	.06	1	1.16	.86	
3	Vegetative spurs	.05	1	1.00	1.00	1
	Fruit spurs	--	1	1.66	1.80	.39
	Shoots	--	1	2.50	5.50	.32
	Miscellaneous	--	1	--	--	.05
	Total	.04	1	1.18	1.48	

The estimates of the numbers of leaves and leaf area in table 2 indicate considerable variability within an orchard managed by the same grower. The sample trees included no aberrant trees, that is, none that had lost major scaffold limbs or that had been pruned drastically to remove diseased wood associated with fire blight. Trees in the same orchard were in the immediate vicinity of one another, thus minimizing the error resulting from site differences. The variability may be partially attributed to pruning practices; each grower has personal pruning preferences that are readily observed. In addition, pruning is usually done by a work crew, and individual practices may strongly affect the future growth of the trees. Over the years, each tree assumes a unique leaf pattern even though it may outwardly appear similar to adjacent trees. Other factors may contribute to the distinctive pattern in each tree, but the pruning history from the time of planting to maturity probably contributes the most heavily to the leaf pattern within the tree. Westwood et al. (4) and Barlow (1) also found varying responses of trees dependent upon pruning.

Further variability is found in the leaf patterns when the trees of several growers are compared. The probable causes of variability include the genetic history of the trees, the pruning practices, fertilizer applications, and the myriad of minor horticultural practices used by individual growers. However, leaves originating on the vegetative spurs were always largest in number and area, followed by the leaves originating on the new terminals and shoots, and finally, by the leaves occurring on the fruit spurs. Generally, the foliage of single leaves or clusters of two were minor in number and leaf area. In general, the leaf area pattern followed that of the number of leaves because only a few square centimeters difference in size was detected among the three major categories of leaves. The sampled vegetative leaves averaged 20.6, 21.0, and 20.2 cm<sup>2</sup> for growers 1, 2, and 3, respectively; terminal shoot leaves 21.9, 21.1, and 24.8 cm<sup>2</sup>, respectively; and fruit spur leaves 15.5, 16.6, 15.9 cm<sup>2</sup>, respectively.

The data in tables 3 and 4 show that the 15-yr-old trees of grower 1 had a different pattern of leaf distribution than the older trees of growers 2 (20 yr) and 3 (23 yr). Less foliage occurred in the fourth meter above the ground and more occurred in the first meter. The trees of growers 2 and 3 have been pruned away from the ground, and the normal shading of the lower portion of the tree by the upper limbs has caused a major leaf shift to the upper portions of the tree; however, the proportion of leaves originating on the various tree parts were similar in the orchards of growers 1 and 2. A shift from shoot leaves to vegetative spur leaves was evident in the orchard of grower 3. Grower 3 employed minimal pruning and fertilization. Thus, the terminal and shoot growth was limited and apparently caused a shift to additional leaves on the vegetative spurs.

The proportion of leaf surface follows that of the number of leaves (table 4), with a slight shift to larger areas of vegetative and shoot leaves that have a larger average size. The leaves associated with the fruiting spurs are usually smaller and, in some cases, are very small. Therefore, the average leaf surface of the fruit spurs is smaller than that of vegetative spurs or terminals.

The numbers of leaves were compared by developing ratios of the total number of leaves from the third and fourth levels of the tree, to the number in

the second meter level (table 3). Evidently, the pruning practices, age of the tree, and other horticultural practices create a unique pattern in each tree and each orchard.

If the determination of the leaf numbers and leaf surface is to be used for research, the research worker must properly evaluate the pattern of leaves in study trees; however, Willett (6) has demonstrated a close correlation between limb diameter and leaf surface, and this may be applied where practical. For practical management of insect populations, the control consultant should be aware that the number of leaves per tree varies appreciably and may affect the distribution of insects. Therefore, the consultant should make approximations of leaf distribution and types and advise the grower on the appropriate pest control practices.

The distribution of the fruit (table 5) was associated with the leaf surface. The mean numbers of fruit per tree for the older trees of growers 2 and 3, were similar, while the yield of the younger trees of grower 1 was less. Growers 2 and 3 harvested about 54.4 metric tons of pears per hectare. In all cases, the relation of leaf surface to the single fruit was strikingly similar. The total leaf area per fruit represents 20 to 25 leaves. Fregoni and Zioni (2) found that as leaf numbers increased to 45 to 60 leaves per fruit, fruit diameter increased positively. At 25 to 32 leaves per fruit, they found a sharp rise in fruit weight that leveled off with a larger number of leaves per fruit. Thus, the three growers apparently approached a highly effective leaf area to fruit relationship.

The study demonstrates that although pear orchards may appear relatively uniform, a great variability exists within and between trees. The apparent failure of the method employed to accurately estimate the total number of leaves, leaf surface, and number of fruit on the tree is a case in point. A study of the limb structure of the 12 trees indicated that the probability of a major limb occurring in the row or perpendicular to the row was 0.56, 0.81, and 0.69, respectively, for the three growers. The probability of a limb occurring at a 45° angle from these row-oriented directions was 0.44, 0.63, and 0.38, respectively, and the probability of a major limb occurring in the eight positions between these angles was 0.25, 0.50, and 0.31, respectively. Even distribution of limbs at 22.5° spacing around the trees would call for probabilities of 0.38, 0.61, and 0.42, respectively, for the scaffold limbs of trees of the three growers. The overestimates, noted in table 1, can be partially attributed to the 1.52:1 and 1.64:1 ratios of the actual expected probability of major scaffold limbs in the sampling zone. Therefore, a projection employing the assumption that the limb and foliage distribution are similar throughout the 360° conformation of the tree must be interpreted with reservations. With adequate tree conformation data, the method is a useful tool for estimating leaf numbers and area.

Generally, foliage distribution was highly variable, suggesting that any insect population estimate that is presented on a leaf basis must take into account the type of foliage and its distribution in the tree. In relating predator searching capability to the area of a tree that must be searched, one must also consider predator and prey distribution in the tree in relation to the leaf surface.

Although the variability may be great, the consideration of these factors will permit a more accurate interpretation of population estimates or better estimate the predator impact than the methods currently in field use.

The distribution of pear psylla eggs and nymphs for 1978 and 1979 is presented in table 6. The preliminary data from 1977 were similar (table 7). Preliminary examination of the data indicated that--due to the clumping of the eggs and nymphs on the spurs, leaves, and shoots and within the individual quadrants--the standard analysis of variance that requires statistically known distributions was not a feasible means of analysis. Therefore, the pooled data from each quadrant were analyzed using the Friedman two-way analysis of variance by ranks (5), with each quadrant a treatment and each date a replicate. The analysis was also used to determine if there were any differences in the population between levels or between trees on each individual date.

There was no significant difference between quadrants, among trees on a given date, or in pooled population data from all leaves for a given date or several dates (table 5) when populations in the three upper levels of the tree were compared. No significant difference was found between the population when the four sides of the tree were compared; however, several trends were apparent. Populations in the second meter above the ground surface were usually higher than those in the remainder of the tree until terminal and shoot growth commenced because of the larger number of fruit spurs in that portion of the crown (period 1, table 5).

When terminal and spur shoot growth began, there was a shift to the new leaves by the ovipositing females and for the remainder of the growth period. The populations of eggs and nymphs were greater on the new leaves on terminal and spur shoots (period 2). After the new growth had hardened (period 3) and after harvest (period 4), the populations of eggs and nymphs were similar on the leaves originating on the fruit and vegetative spurs and the terminals.

The propensity of the ovipositing female to seek new foliage was obvious during period 2 (table 6). In 1979, the trees had limited terminal and shoot growth, and the inclination is generally masked. In early season, the fruit spurs and the leaves originating on the fruit spurs were apparently preferred as oviposition sites by the female psylla. Therefore, the orchard manager or consultant must realize that the populations of pear psylla eggs and nymphs are appreciably larger in the portion of the trees in which the fruit spurs are common and, later in the season, on the new leaf growth of the terminals or shoots. The distributions of the fruit and vegetative spurs, and shoots, in a tree are highly variable and are probably dependent upon the pruning, fertilization, and general horticultural practices of each grower. Although the fruit spurs are distributed over the tree fairly evenly, a larger proportion of the new shoots occurs in the top of the tree and thereby concentrates a major portion of the pear psylla population. Therefore, the grower must place adequate deposits of insecticides directed at the pear psylla in the upper portion of the tree.

The predator and parasite distribution presented in table 8 shows a slight trend for the predators to be in the lower portion of the crown of the tree. Due to the timing of the predator population assessment (period 1, table 6), this may be interpreted as direct association with highest immature psylla populations.

Table 6.--Mean numbers of immature pear psylla at 3 tree levels on 3 types of pear foliage

Mean numbers of pear psylla eggs and nymphs per spur or leaf:										
Tree part	Height (m)	Period <sup>1</sup> in 1978					Period <sup>1</sup> in 1979			
		1		2		23-4	1		2	3
		Spur	Leaf	Spur	Leaf	Leaf	Spur	Leaf	Fruit	Leaf
Sampling unit										
Fruit spur	2	333.8(5)	4.7(8)			(6)	70.0(5)	5.4(7)	4.2(5)	0.6(9)
	3	31.6	4.4			(6)	58.7	3.7	2.5	.6
	4	22.0	5.1			(6)	30.4	3.7	2.6	.7
Vegetative spur.	2	29.0(1)	4.0(9)			1.0(9)	6.9(1)	2.1(7)	.8(10)	0.4(4)
	3	19.9	4.7			1.2	5.5	2.3	.7	.5
	4	20.6	5.9			1.5	8.5	2.7	.8	.5
Terminals: <sup>4</sup>										
New <sup>5</sup>	2		14.9(8)			(7)		2.5(6)	(8)	(8)
	3		16.2			(7)		2.8	(8)	(8)
	4		19.4			(7)		3.4	(8)	(8)
Old	2		5.7(7)			1.4(8)			1.2(9)	.5(5)
	3		6.9			2.2			1.6	.7
	4		10.7			2.4			1.5	1.0

<sup>1</sup>1978: period 1, March 27-May 1; period 2, May 8-June 26; period 3-4, July 3-August 28. 1979: period 1, March 29-April 23; period 2, April 30-June 11; period 3, June 18-August 13; period 4, August 20-September 17.

<sup>2</sup>Periods 3 and 4 combined. Fruit lost early to codling moth.

<sup>3</sup>Numbers in parentheses note number of sample weeks. Four trees sampled each week.

<sup>4</sup>Includes all new terminals and "water shoots."

<sup>5</sup>New, latest 6 expanded leaves on terminal; old, all other leaves on terminal.

<sup>6</sup>All spur leaves considered vegetative after fruit picked.

<sup>7</sup>All shoot leaves considered old after fully mature.

<sup>8</sup>Terminal growth terminated by end of period 2. Thereafter, matured leaves were considered old.

Table 7.--Distribution on pear psylla eggs and nymphs in pear trees, Yakima Agricultural Research Laboratory, 1977

Portion of crown	No. of immature pear psylla per spur or leaf:			
	Period <sup>1</sup>			
	1	2	3	4
	No. per spur	No. per leaf	No. per leaf	No. per leaf
Top one-third	31.8	1.2	0.8	1.9
Mid one-third	39.1	1.2	0.6	0.9
Lower one-third	64.5	1.8	0.6	0.9

<sup>1</sup>Period 1, March 21-April 25; period 2, May 2-June 27; period 3, July 4-August 29; period 4, September 5-October 3.

Table 8.--Numbers of pear psylla and beneficial insects at 3 levels in pear trees

Date	No. of insects at indicated level above soil surface					
	Immature pear psylla per leaf <sup>1</sup>			Predators and parasites <sup>2</sup> per samples <sup>3</sup>		
	2 m	3 m	4 m	2 m	3 m	4 m
Apr. 23	161	169	116	15	4	5
30	143	120	119	11	1	7
May 7	20	15	13	14	2	5
14	13	8	10	8	4	6
21	6	9	11	7	1	7
28	1	4	5	10	8	2
June 4	11	7	11	10	8	2
11	6	7	9	9	7	3
18	5	5	10	4	3	0
25	6	8	8	4	1	5

<sup>1</sup>April 23 and 30 the sampling unit was a fruit spur.

<sup>2</sup>Includes *Trechnites* sp. adults; all stages of hemipteran predators, mainly *Anthocoris* spp. and *Deraeocoris* sp.; all stages of ladybird beetles, mainly *Adalia bipunctata*; all stages of spiders; and the predatory stages of other species.

<sup>3</sup>All samples consist of examination of 10 fruit and 10 vegetative spurs plus 10 terminals from each of the 3 levels of 4 trees on each date, except no terminals on April 23.

Overall, the difference is not significant, and the predators and parasites appear in the trees in about the same relative distribution as the immature pear psylla (table 6). The relatively even distribution may be explained by the fact that the populations of immature pear psylla were relatively large and food for the predators and oviposition sites for the parasites were available throughout the tree. When populations of the pear psylla decline to a low level, the mobile predators and parasites leave the orchard. Therefore, the beneficial insects are probably more sensitive to the general presence or absence of food and oviposition sites than to the actual distribution of prey or hosts in the tree.

The distribution of the pear psylla in individual trees again demonstrates the variability in the distribution of insects in their environment. These clumped distributions impose severe restrictions on the statistical approaches to the analysis and evaluation of sample counts for population estimates. A similar variability in the distribution of pear foliage in trees in commercial pear orchards provides additional complications in population analysis. Set sampling or evaluation schemes will provide working data for all orchards; however, research workers and field men should be flexible in their interpretations in light of the physiological condition of the trees and the leaf growth patterns. Field men and growers must also insure that applications of controls for pear psylla populations be directed to most physiologically active portions of the tree. Research workers evaluating low key control measures, such as biological control, must take into account the variable patterns of the populations of pear psylla and attending biological control organisms in the pear trees.

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